FOSSEE, IIT Bombay
OpenFOAM Case Study Project
June 15, 2025

Dynamics of solids connected by liquid bridges with contact angle hysteresis

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Abstract

This report presents a comprehensive analysis of two-dimensional (2D) computational fluid dynamics (CFD) simulations conducted using the OpenFOAM interFOAM solver. The primary focus is on multiphase flow phenomena, with a particular emphasis on the intricate dynamics of contact angle hysteresis. The central investigation involved a rotating cylinder immersed in a two-fluid system, where two distinct contact angle hysteresis models were implemented: a static advancing/receding angle model and a dynamic feedback deceleration technique. To ensure the robustness and accuracy of the numerical methodology, three critical benchmark cases were performed. These included a squeezing flow problem, a Stokes drag comparison, and an analysis of Laplace pressure drop for a cylindrical droplet. The simulations achieved successful validation against established analytical solutions and theoretical principles. Specifically, the squeezing flow benchmark demonstrated the breakdown of lubrication theory at higher Reynolds numbers, while the Stokes drag comparison affirmed the Galilean invariance principle in low-Reynolds-number flows, and the Laplace drop test affirmed the Laplace pressure drop across an interface.